

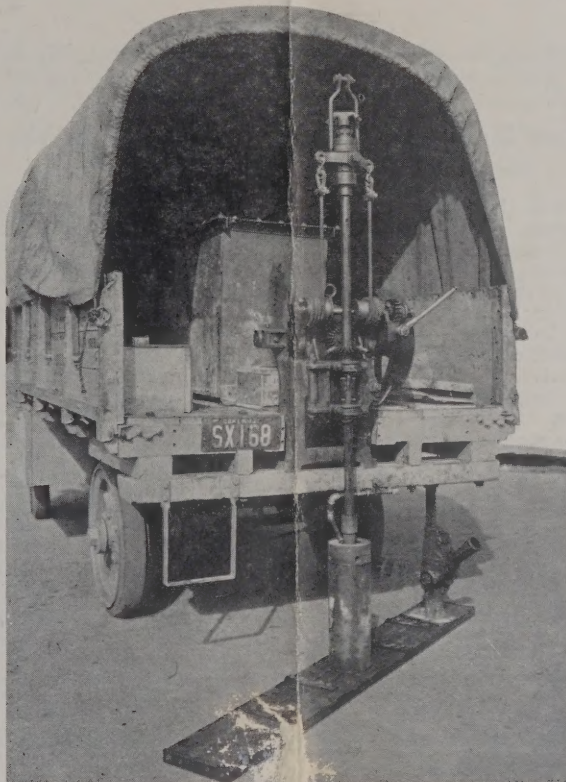
The Highwayman

Tractor with Locomotive Type Snow Plow
on Route 13, Lawrenceville-Princeton

March,
1922

Road Builders' Supplement

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No. 8



THE CALYX CORE DRILL

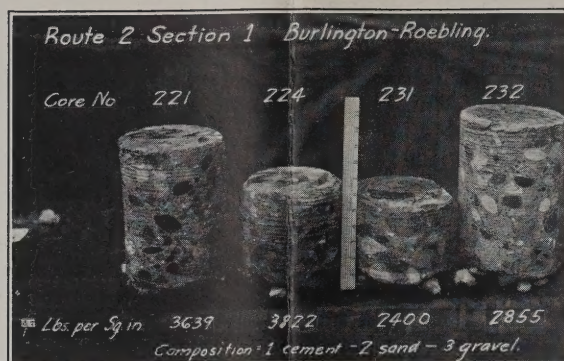
This machine is saving the tax-payers of the country hundreds of thousands of dollars on road-building. Its construction and operation are described in the following article. Even if you are not engaged in the business of road-building you will find the account of this machine and its work mighty interesting.

Note

The papers presented at the recent Convention of the New Jersey Highway Association, and the discussions following them, are such a valuable contribution to the progress of road-building that it has been decided to publish them in full with as many as possible of the charts and illustrations used. (It has not been possible to include all of these, however, so there are occasional references in the text, to photographs and charts which have not been reproduced).

Our aim is to publish one or two of the Convention papers, with the discussion thereon, each month. We suggest that these be carefully filed, so that the reader may keep the complete set, which will make a very valuable addition to his road-building library.

This month we are printing "The Calyx Core Drill, and other Rock Drills for the Road Builder"; and also "The Organization and Operation of Motor Vehicle Equipment." Next month there will be published "Merits of Fine Gravel As Coarse Aggregate in Concrete for Roads", by J. M. Braly; and the discussion thereon at the convention; also "Recent Developments in Concrete" by H. C. Boyden, of the Portland Cement Association.



Photograph No. 37

Compare these cores with those shown in photograph No. 55 on the page opposite. The aggregate was the same in both cases: 1, cement; 2, sand; and 3, gravel, and yet— (see page 18)

The Calyx Core Drill and Other Rock Drills for the Road Builder

By G. W. Morrison, Ingersoll-Rand Company

The company which I represent has had an Engineering and Research Department for a number of years. The function of this Research Department is to help solve the various problems of different industries and demonstrate to them that their work can be done better, quicker and cheaper by the methods we recommend than by those now being used or followed. In all probability we have available data on the problems you are now trying to solve. Our Engineering and Research Department is at your command and will gladly help solve your problems.

When road building began to receive so much attention a few years ago, we brought out a core machine suitable for road work. We called it a "Paving Tester." By means of it a 6-inch diameter sample core can be quickly taken of any existing or proposed road bed or road surface. By subjecting the samples to laboratory tests a complete understanding can be had of existing conditions and future plans made accordingly.

The accompanying photograph shows this machine better than it can be described. Your own Department have one of these outfits, and I understand they have made excellent use of it. I suggest you ask Mr. Gage to tell you about his work with it. I am sure his experience along that line would be very interesting to all. I happen to have a fairly complete report of what your neighboring State, Pennsylvania, has done with their outfit. I will try to describe it as best I can. Should Mr. H. S. Mattimore, Engineer of Tests, be present I would be glad to have him correct me if I get my facts or figures mixed.

They employ the machine to meet new conditions, and in determining the fitness of existing roads and to deduce basic principles for planning future highways.

For convenience, the equipment of the Testing Department may be divided into field or road equipment and laboratory equipment.

The field equipment, being necessarily portable, is carried in a three-ton army truck equipped with a five-ton engine, and consists of the following.

- (1) Pavement-Testing "Calyx" Core-Drilling Outfit, complete.
- (2) Apparatus for determining bearing power of soil.
- (3) Molds for concrete repair plugs.
- (4) Bins for cement, sand and stone for repair plugs.
- (5) Accessory tools for the work and any necessary repairs.

The photograph below shows the general arrangement of the component parts of the Calyx Pavement-Testing Outfit on the truck.

The drill head is a patented type especially designed for road-testing service, capable of taking cores from two to ten inches in diameter from hard pavements. Proper strength of rotation and simultaneous control of bit pressure are the functions of the drill head. The best results in drilling are secured by providing a pressure device which gives the operator complete control of pressure on the bit while drilling. By means

of a convenient ratchet wrench and worm gearing, hand pressure is multiplied about thirty times in its exerted pull on swivel and consequent pressure on the bit. Rotation of the bit is effected by the drill head spindle which is a hollow shaft with sliding fit in a keyed journal driven by bevel gears from the belt wheel.

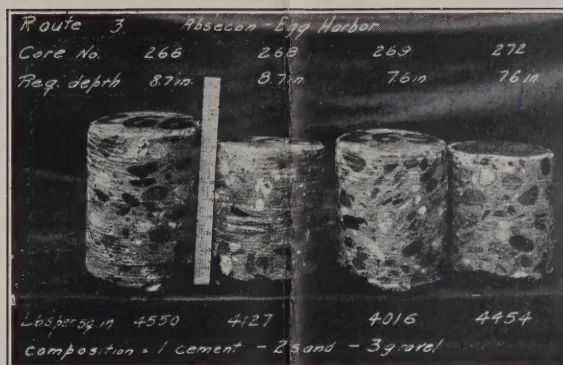
The drill head is driven by belt from an eight H. P., two cylinder, four cycle, gasoline engine mounted in the forward end of the truck box with its own radiator and gasoline tank, so as to be independent of the truck for power or supply. The end gate of the truck has been removed to allow the Calyx drill head to be mounted flush with the end of the truck box.

Mounted back of the Calyx drill head is the water tank with capacity of 130 gallons. A hand force pump is supplied and carried with the equipment in case of an emergency, so that the tank can be refilled from creeks or rivers. Ordinarily not over three gallons of water will be used in drilling a core from an eight inch pavement, thus insuring adequate water supply for more than a full day's work.

Perhaps a word of explanation regarding the fundamental principle of a Calyx drill might not be amiss at this juncture. The drilling tool is a soft cylindrical bit with a flat or slightly rounded face rotated approximately 200 revolutions per minute on a thin layer of steel shot fed through the bit and lying between the bit and the material to be drilled. Pressure is exerted on the bit as it rotates breaking the shot into fine sharp edged pieces. These pieces being hard and brittle partially imbed themselves in the face of the soft steel bit and are dragged along by it, thus abrading the material below the bit and, of course, the bit itself to a very small extent. A slot is cut in the bit in such a manner as to continually work the steel shot to the cutting face and allow them to be crushed between the bit and the pavement. The shot as mentioned above are supplied through the inside of the bit and tend to work toward the outside but are caught by the slot and again forced under the bit. This cycle repeats until the shot are ground to a fine powder light enough to be carried to the surface by the water.

The water is fed to the cutting face to perform the double function of keeping the bit cool and at the same time wash the cuttings from the hole. As the drilling progresses a cylindrical ring is cut away and the core protrudes up inside the bit. When the hole has been drilled through the pavement, the bit is raised and the core lifted out and marked for future identification when shipped to the laboratory in Harrisburg where it is tested as described later. A clearer conception will be gained by noting the following slide of actual equipment and operation.

The field men have added an ingenious device of their own invention to counterbalance the spindle weight and quickly raise the bit during or after completion of drilling. A wire rope from the swivel running over a series of sheaves is attached to a sliding counterbalance weight on the side of the truck hood. By loosening one bolt the upper sheave over the spindle



Photograph No. 55

There were more cracks in one 900 foot section of the one pavement than in 9 miles of the other. It is easy to tell which contractors gave the State the most for his money!

(see page 18)

can be lowered when not in use in case of very low head room.

The State Engineers of the large number of States now using this drill are practically unanimous in their opinion that proper investigation of core, sub-grade conditions, thickness of pavement, wear, test, crushing strength and uniformity of mix requires a core at least 6 inches in diameter. Consequently the majority of States have practically standardized on the 7½-inch bit, which takes a core approximately 6¼ inches in diameter.

In starting a hole on the flat surface of the road a guide board is used for centering and holding the bit in place. After penetrating a half inch it is no longer necessary to hold the board as the bit has made its circular groove which holds it in place. A ring of wet waste or rags circled around the bit and jammed between the board and the pavement has been found by some operators to be a big help in starting the hole as the waste holds the shot to the bit. Shot should be fed at small intervals and in small quantities. An ounce or two at a time is better than larger feedings at longer intervals. A 7½-inch bit will drill through an 8-inch concrete pavement in a period of fifteen to twenty-five minutes, depending on the experience of the operator, as well as the mix and age of the concrete or other hard surface. Three pounds of shot (which cost approximately 21 cents) will be found ample allowance for each hole.

Care should be taken not to use too much water, because the bit does its best work when working in a thin sludge of ground shot and rock with sufficient water to carry to the surface only the finest rock.

Apparatus for Determining Bearing Power of Soil

The apparatus for determining bearing power of the sub-grade is an auxiliary piece of equipment specially designed by the Pennsylvania State Highway Department's engineers. It is still experimental in construction, but promises to become an important part of the standard equipment.

The equipment is shown by the accompanying photograph and may be briefly described as follows: A collapsible tripod with telescopic legs supports a compound lever mechanism for exerting known pressures to a penetration rod. The exerted pressure tends to lift the tripod, but is prevented from doing so by the use of two holding down rods with special heads which hook under the pavement through the drilled hole. By a series of notches the penetrating rod is lowered to the varying height of the subsoil and the lever arm adjusted to a horizontal position. When the core has been removed after drilling, and also the thin layer of soil dampened by the water used, the tripod is set in position for the test. A graduated Ames dial indicates the depth of penetration in the sub-grade for the load is applied when weights are hung on the lever arm. Time readings are taken, so that the rate of penetration may be computed and the bearing power determined.

When starting a trip, the core drill crew is furnished a complete itinerary with exact locations on the various roads to be drilled. In addition to this, however, they are directed to drill cores from and take observations

at any unusual condition encountered. They average three to four cores per mile, or approximately one every 1,500 feet, plus the extras for unusual conditions.

It takes an average of 20 minutes to drill a core 8 inches in length from a concrete road; about 5 minutes suffices for the bearing pressure test. While the engineer is making the latter the mechanic is substituting a soil drill bit in place of the concrete drill bit and a 1 or 2-foot soil core about 2½ inches in diameter is removed. These soil samples are for laboratory study.

While traveling from one location to another concrete repair plugs are cast in special molds for this purpose. The diameter of these is a little smaller than that of the bored hole. A four (4) per cent. solution of calcium chloride (CA C₁₂) is used in making the mix, this appreciably accelerates the set. It is only a moment's work to place and grout one of these repair plugs with quick-setting cement, so that, when the testing outfit moves on, the road is left in good condition.

The outfit averages 16 cores per day.

The success or failure of the finished road is largely dependent upon the quality and suitability of the materials used in construction.

In the testing laboratory all basic road materials are given thorough physical and chemical analyses. Varying proportions mixes are made and cast into cylinders or "cores." These latter are put through the compression and impact tests.

During the construction of a concrete pavement, certain States require that test specimens be cast from a representative batch of concrete for each unit of pavement constructed. These units may represent from 500 to 3,000 square yards of pavement, but generally about 1,000 to 1,500. The specimens thus secured are sometimes tested at the age of seven days, but generally not until they are twenty-eight (28) days old.

Later, drilled cores are taken from the completed road at approximately the same location. When these latter cores are tested, the results obtained are usually what was to be expected from the data obtained from the cast "specimens." Frequently, however, wide variations will be noticed. It is the drilled cores that tell the real story. Their bottom surfaces show the condition of the sub-grade. The cores will show if the mixing, placing, finishing and curing were done correctly. The drilled cores are virtually X-rays of the finished road and are the most reliable source of information.

Some conclusions drawn from data derived by means of the impact testing machine are:

1. The qualities of both coarse and fine aggregates influence both compression and impact wear tests.
2. The quality of the fine aggregate has a greater effect on the impact wear test than that of the coarse aggregate.
3. A 1:2:3 mix gives more uniform results in impact wear test than a mix with a larger proportion of coarse aggregate.
4. The 1:2:4 and the 1:1½:3 mixes are affected to a greater extent by the qualities of the coarse aggregate than a 1:2:3 mix.
5. Where an excellent quality of fine aggregate is

to be used with a medium quality of coarse aggregate, a 1:2:3 mix should be used.

6. Where an excellent quality of coarse aggregate is to be used with a medium quality of fine aggregate, there is very little difference in impact wear between a 1:2:3 and a 1:2:4 mix, so it may be economical to use the latter.
7. More uniform results were obtained under impact wear test on specimens drilled from the road than on moulded specimens.
8. There is no direct relation observed between wear test and compression.
9. Machine finished concrete gives more uniform results in impact wear tests than hand finished concrete, although some specimens of the latter give high values.

A description of their compression (crushing strength) testing machine is not necessary. It is a standard universal testing machine.

Another feature which should be interesting to the road builder is that the pavement drill can be used for testing foundations for dams, bridges, etc. To do this work, however, some additional equipment is required, such as a set of Calyx drill tools and matching coupling, drill rods, etc. We would suggest size 3 or 3½-inch Calyx tools, as the cores secured with these sizes of tools are sufficiently large to give the required information.

Portable Compressors

Before the advent of the Jackhammer it was quite common practice to operate the reciprocating type of rock drill by steam. This was due to the length of time required to install a compressed air plant, and the cost of the compressor. This condition has now been changed. With few exceptions, the road builders' drilling problem finds its most satisfactory answer in the Jackhammer, a light-weight, self-rotating, hand hammer drill. This machine will put down holes of 6, 12 or 20-foot depth, according to its size, and yet is so easily handled that the holes can be drilled at any angle and in any place that affords a foothold for the drill runner. Jackhammers are the accepted standard, not only for the light work, such as removing out-cropping ledges, but also for heavy excavation bench work and tunneling. Jackhammer, by the way, is a trade-mark name, registered in the United States Patent Office.

The Jackhammer is now made in five weights or sizes. The three largest ones are made for use with steam or compressed air. These may also be equipped with arrangement for feeding water as well as air through the hollow piston and steel to the bottom of the drill hole to allay the dust and remove the cuttings.

Most of our Jackhammers will run on steam, but not nearly so efficiently as on compressed air. Therefore, good practice calls for an air compressor which is, first, reliable; second, easily portable; third, efficient; fourth, reasonable in price.

The development of the automobile engine and the many improvements in air compressor practice, coupled together, made it possible for us to solve the problem and furnish you with a portable outfit which fulfills the above condition. Such machines are now available in several different sizes, each designed to operate a certain combination of tools such as are customary in road building, quarrying, contracting, and other construction work. The illustration herewith will give you a good idea of the construction of these portable compressors. You will notice that they are operated by four cycle, four cylinder tractor type gasoline engines of proven design. The compressors are vertical and perfectly balanced. They are designed so as to give maximum strength and wearing qualities with the least possible weight. The radiator, air receiver, fuel tank, top and side curtains and all other accessories are arranged so as to make the machine compact yet easily "get-at-able." The entire outfit is mounted on a substantial steel truck.

The common practice is to haul these portable compressors from place to place with a team of horses at not to exceed a speed of six miles per hour, but necessity for quick transportation to distant points, such as public service work, has led a number of our customers to remove the wheels and axles and mount the outfit in standard auto trucks and trailers so that they may be moved at a speed up to 12 to 14 miles per hour.

For an air plant of slightly greater capacity it is possible that a skid-mounted compressor may be preferred to a road portable machine. An outfit of this kind is fully self-contained, yet light weight and handy enough to permit convenient loading and unloading when being moved on the contractor's truck.

Where electric current is available a motor-drive compressor may be employed, retaining all the advantages of simple electric drive.

Where electric power is not available a steam machine, skid mounted, may be used. The steam is furnished by a portable boiler. An outfit of this kind is fully self-contained and sturdy, yet light weight and handy enough to permit convenient loading and unloading when being moved on a contractor's truck. The larger types of compressors are purely stationary.

Allied closely with actual road construction is the quarrying of stone for foundation, sub-surface or surface of the street or highway. There are three types of drills in most common use in quarrying: The well or churn drill, the "Sergeant" or tripod-mounted piston drill, and the Jackhammer drill. Each of these types of drills has its use in the quarrying of stone.

The proper field for the well drill is in such rock as laminated limestone or cement rock, i. e., for drilling such rock that will come down well broken up, after the powder gives it a good shaking-up and the rock falls from a fairly high face. (Well drills are used practically exclusively on high face, of course.) In hard rock it is very difficult to start a well drill hole and the drilling speed, of course, is much slower. Some rocks have been encountered that were so hard it was not practical to drill them with well drills.

When well drills are used in granite, trap rock, hard limestone, etc., there is usually an immense amount of secondary drilling to be done so that the blocks may be broken up in sizes that may be handled by the shovel. At times the cost of this secondary drilling and blasting exceeds the initial drilling and blasting costs, as well as interrupts the operations of the shovel crew.

Another point, in one well drill hole it takes a certain amount of powder to break the ground. In another hole nearby merely half the powder might do the work because of formation or strata differences, but there is no sure way of determining this so each hole must have enough powder to break the ground under the most adverse conditions. A lost well drill hole means a considerable monetary loss.

A very good average drilling speed for a churn drill in fairly hard rock is about twenty feet a day, two men operating the drill.

The "Sergeant" or tripod drill, with which I believe you are too familiar for me to describe it in detail, is at its best when working on twenty-five to thirty-foot holes in brecciated, non-homogeneous, "poor-mudding," or "heavy drilling" rock. Here the heavy crushing blow and churning action of the reciprocating drill steel are very advantageous. Even in this kind of ground, however, it has been found in a number of cases that the use of the Jackhammer type of drill on shorter benches is more efficient.

Sixty feet of hole drill per shift is the good average for a tripod drill with two men.

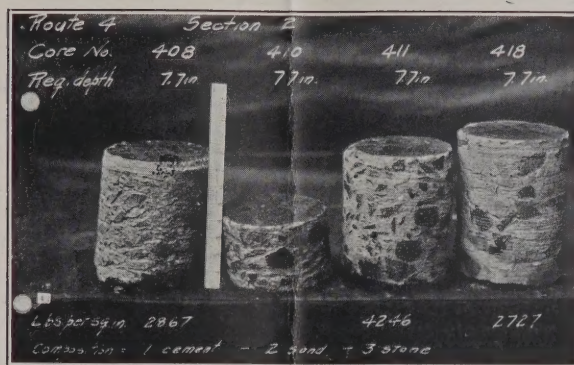
One man with a Jackhammer drill can average 150 feet of drill hole per day, in the same kind of rock for which the drilling speeds of the other two types of machines were given.

There are many other advantages in using Jackhammer drills. They are very light and easily handled. No mounting is needed for them and no time is lost in making "set-ups." It is a matter of only seconds to start a drill hole with a Jackhammer. Drill holes may be placed easily and to best advantage. The powder may be properly distributed to break the ground most economically. The blasted rock is broken up in sizes which may be handled directly by the shovel without any secondary blasting.

When working fifteen to twenty-foot benches with Jackhammer drills, the work is much more continuous, labor may be minimized and the entire undertaking carried on much more economically and efficiently.

Paving Breakers

One of the new tools recently placed on the market in which road builders are interested is known as the "paving breaker." Its greatest use is for cutting asphalt



Photograph No. 42

These cores were taken from the section where the State paid for 6 to 8½ in. of concrete and got only 4 in. This section has cracked badly under heavy traffic. (see page 18)

and breaking out concrete. In appearance it somewhat resembles a Jackhammer. It has a trigger throttle easily manipulated. It has no need for a rotating device and the piston strikes a straight hammer blow which drives the pointed steel into the solid concrete and wedges off chunks easily handled by one man. Two men, each with one of these machines, and a portable compressor does the work of fifteen men. Their greatest field is in cities where old pavements have to be removed. However, the tremendous changes in road requirements may soon make it necessary for some of our older concrete highways to be relaid, and if so it will be a great help to you. Public utilities find them a great help in laying conduits, enlarging manholes, etc.

Sand Rammers

The pneumatic sand rammer used in foundries is often a great time and labor saver in tamping back fill, especially where paving has been removed and a trench dug for water or gas main or wire conduits. By tamping the fill with these pneumatic machines settling and misalignment of pavement is avoided.

Tie Tampers

Occasionally the road contractor has some railroad or street-car track to lay. Where such track has to be tamped pneumatic tie tampers greatly reduce labor cost and insure a much better track. These tools are very widely used by the transportation lines throughout the country.

Leveling Joints in Concrete Roads

When driving over concrete roads which have been laid for two years or more, one generally notices that the joints are higher than the rest of the surface. Considerable study has been given to this matter recently, due to the fact that engineers realize that a high spot causes a wheel of a truck or other heavy vehicle to strike a blow when it next comes into contact with the road surface after leaving the high spot. It does not take long for succeeding blows to start a hole, and when a hole is once started it soon assumes serious proportions and means a repair job. We are told these high spots are the natural result of the leveling board as it comes against the end form when the finishing coat is being leveled. As it seems impossible, or at least

impractical, to eliminate these high spots in the pouring and finishing operation, they must be worked down after the concrete is set. This can be done by means of small hand or pneumatic tools, known in the cut-stone business as bush hammers, but either is a slow and expensive method, and much faster tools are advisable. A Jackhammer equipped with a bush-hammer type of bit has recently been suggested. It seems to have great possibilities, on account of its much greater size and power. It requires, however, closer regulation than is necessary for the ordinary rock drilling. To get the closest regulation and make the work easy on the operator we have suggested a two-wheel cart mounting with control levers running back to the handles of the cart.

This entire subject is still comparatively new and much thought will be given to it during the coming season.

General

The tools described above are those that the road builder is the most interested in, but there are many other types of pneumatic apparatus that you may or may not encounter, depending on the peculiar conditions surrounding each particular job. For instance, you may operate your own quarry, and in that event will need a stationary air compressor and possibly other types and sizes of rock drills, hoists, pumps, etc., and in this connection the following slides will be of interest.

There is one more thought that I would like to leave with you, and that is, in buying compressors don't buy too small a machine. You will always find more and more work that can be done most economically by compressed air, providing you have the compressor capacity to operate the necessary tools. I have yet to be criticized by a customer for selling him too large a machine, but many, many a time a customer has said to me: "Why did you not force me to buy the larger compressor when I bought last year? If I had it now I could run one more drill, or I could operate a hoist or scraper. The difference in first cost would not have been much, but now I will have to buy a complete additional machine." So I say to you, listen carefully when you are advised to take the larger compressor. If our experience can be considered typical you will find that it pays to buy the bigger unit.



Calyx Core Drill

Discussion of the Preceding Article
by R. B. Gage

Chemical Engineer, New Jersey State Highway Department

Mr. Morrison has stated that the data they have collected indicates that a core can be cut from a concrete pavement eight (8) inches in thickness, in from fifteen to twenty-five minutes, depending upon the experience of the operator. The experience New Jersey has had with their Calyx core drill does not permit the writer to agree with these statements.

It may be that Mr. Morrison's data is based upon samples taken from pavements that were not of the proper density or else constructed from soft aggregates, but the writer feels very safe in saying that an operator would have to work with lightning rapidity to cut a core from a New Jersey pavement in this length of time. We have considered that our operators were making very good time if they cut ten cores per day, the average most generally being about eight. As the density and strength of these pavements increase, it is to be expected that the time required to cut cores will also increase accordingly.

Again, some of the conclusions stated by Mr. Morrison, which were based on specimens taken from various pavements by the use of the core drill, have previously been quite definitely established by laboratory tests made on specimens prepared both in the laboratory and in the field. It is, however, quite gratifying to know that results thus secured agree with those based on laboratory tests.

On the other hand, Conclusion No. 7 should be interpreted very cautiously, for while more uniform impact tests may be secured on specimens taken from a pavement, the compressive strength of the samples thus secured are not any more uniform than the moulded specimens cast during the preparation of the concrete.

If the benefits to be secured by the use of this core drill were limited to the conclusions thus enumerated, it is very doubtful if the results thus secured would justify the expenditure. However, the writer is pleased to state that the benefits derived from the use of this machine by the State of New Jersey has not been limited to any such extent.

It has been the custom in the past to assume that a concrete pavement or foundation would have the required thickness, density and compressive strength. How could it be otherwise? It was constructed under the supervision of a State Highway Inspector whose specific duty was to see that the concrete was properly prepared and the pavement had the required thickness, density and strength; further, the reputation of the contractor would be ruined if it was found that the pavement was not of the proper quality or thickness, since it is generally known by whom the pavement was constructed.

The core drill has shown us that we have been traveling more or less in the dark and that our assumptions were not justified. It is very seldom that a pavement or foundation has been found to have the required thickness at all points. It is doubtful if over seventy-five (75) per cent of the cores cut showed the pavement to have the required thickness. Since the specifications require the use of a definite quantity of cement per cubic yard of concrete and the quantity of concrete thus prepared is usually secured from the square yards of pavement constructed, it naturally follows that no change should be made in the proportions of the ingredients being used to correct the cement content unless it is definitely known that the excess or shortage of

cement is not caused by an improperly prepared sub-grade. The core drill has shown us that the above is usually the case.

Again, the loss to the State of a square yard of concrete one-quarter ($\frac{1}{4}$) inch thick is not a very serious one, yet when this extends over a mile of 18-foot pavement it amounts to 73 cubic yards of concrete. It is not uncommon, however, to find sections of a pavement one inch or more deficient in thickness, consequently, the loss to the State per mile of 18-foot pavement will often amount to over \$4,000 at present prices. This loss per mile multiplied by the number of such miles constructed per year will make a net yearly saving to the State of several thousand dollars.

The correction of these errors in construction have already saved the Department more than the entire purchase price and cost of operation of this drill. These facts are of special interest at this particular time, for in some localities a serious effort is being made to have requirements inserted in future specifications which will compel the governing body to pay for all excess cement used over that specified, yet, as above shown, the use of this excess cement is usually caused by the contractor not properly performing his duties, in that the sub-grade was not brought to the required elevation.

The variation in the character of the concrete between different sections of the same pavement, also, between different pavements, is very nicely shown and easily determined by these cores. Samples were cut from various pavements at definite intervals, except where the pavement shows signs of premature failure. At such places, additional cores were cut, also cores were cut from the adjacent concrete which was normal. The data thus secured has been of great value to the Department in detecting the causes of these failures, for in most cases it has been found that the cause of these premature failures can be traced directly to inferior methods of construction.

Another condition which has been long suspected but never definitely known or determined before the advent of the core drill was the injury done to a concrete pavement by any method of finishing that caused the excess water to collect in the upper part of the pavement without removing it. Some of the cores show very distinctly the injurious effect of this excess water in the top of the pavement, also the effects on the character of the mortar in the bottom of the pavement by having the superfluous water absorbed by the sub-grade. Cores illustrating these points are on exhibition in the laboratory and the writer hopes that each one who is interested in this subject will examine these cores during this Convention.

Some of the cores from each pavement have been photographed. The cores were usually selected so as to show the extreme and average character of the pavement, also defective slabs or sections. After being photographed the cores were tested and the data thus secured were recorded on the negative.

Your attention is called to the difference in strength and variation in thickness of the cores shown below in photographs 37 and 55. There are more cracks in one 900-foot section of the one pavement than in nine (9) miles of the other. It is not necessary to state which one has the more cracks, yet both were constructed of practically the same composition and aggregate.

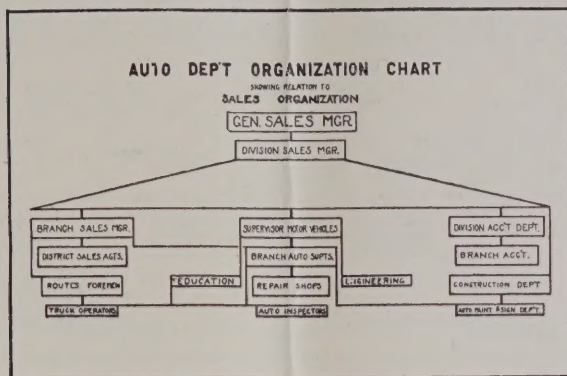


Chart No. 2

This chart, which is the result of ten or twelve years direct experience in motor transportation, indicates the relation of the motor vehicle department and the balance of the organization. It shows also that the supervisor of motor vehicles has under his direct supervision the inspection and mechanical up-keep of the outfits. (see page 20)

Organization and Operation of Motor Vehicle Equipment

By J. F. Winchester, Supt. of Motor Vehicles, Standard Oil Company, N. J., Member S. A. E.

Fundamentally, the operation of motor vehicles for profit or business purposes is like any other business—it must be organized. To make a success of a business of this type, the party venturing into it should study the various angles of the particular line he intends to pursue, and then carefully outline his course of action, with the full realization in mind that there is no line of business that presents as many possibilities for “leaks” as an unorganized motor bus or truck business.

Those of you who have watched the coming and going of various bus and trucking concerns in the last few years have no doubt realized that something was wrong. My observations have led me to believe that the missing link has a lack of true appreciation of the various factors entering into an operation of this kind. These factors were lost sight of by the various interests, one of whom is the small operator, who, because of the lure of easy payments and large profits held out by various sales organizations, went into business and lasted for the time being, or while there was an abnormal demand for transportation facilities, and also by some of the larger companies, such as public utilities, who have failed to realize, and do today, that through proper organization of the various factors entering into motor transportation, they are able to operate a fleet cheaper than the individual operator of one or two outfits, and through co-ordination of this type of service with the present-day facilities, such as water, steam, established express companies, or trolley service, that they are able to render to the public a modern type of service for which the public are willing to pay, in many instances, a premium, because it facilitates the transportation problem and results in a material saving of time being effected, and, in the majority of instances, within a limited radius. Transportation of this kind, through organization, can be put on a profitable and stable basis.

Consider for a few minutes an illustration of a hazardous installation, of which there have been many in the motor trucking industry. A business concern decides to become up-to-date; they will motorize, they study catalogues, call in salesmen, and finally decide on a certain type of vehicle because they are impressed with the looks of it or its sturdy construction, or were impressed with the promise of service that had been made by the salesman.

The machine is received, the old employe is laid off—lack of time and expense preclude the teaching of the horse-drawn vehicle driver how to operate the new outfit—and the new vehicle is placed in the hands of an experienced chauffeur. It does the work fine for a few weeks, then lack of inspection results in its having trouble, delays result, indifferent repairs are made, continual expense is entailed, and in a short time this concern feels that they have joined the class of “all going out and nothing coming in.”

If this same concern was considering putting in an

electric motor, a steam boiler, or some similar piece of equipment, invariably a consulting engineer or a man trained in other than sales line, analyzes the problem and receives a fee for his services. After the machine is installed it is placed under the supervision of a competent or licensed engineer, the grade of license depending on the equipment to be handled or the skill required, and, while it may be stated that all professional chauffeurs require a license before being permitted to drive on the public highway, this license in no way indicates his skill from a mechanical standpoint, and, in many cases, because of the laxity in drivers' examinations and the possibilities of getting by through influence, a license to operate is but little indication that the party so licensed is a competent operator.

Again, compare a five-ton installation that costs from \$5,000 to \$6,000, or even \$7,000, and then requires an annual expenditure in some lines of work of a like amount for operation, with that new highway engineer whom you are thinking of engaging next season at a moderate salary.

You will size up his age, health, experience, personality, recommendations, and when he starts in you will advise him carefully how he should fit himself into the organization. Your bookkeeper will check his expenses and salary against certain contracts; you will measure his efficiency, and are ready to do so because you consider it good business. Have you considered the contrast between the way you and others check your investment in this human equipment, who has every incentive for efficiency, as against the inanimate piece of machinery which can only produce profits if properly supervised?

I only picture these past occurrences and analyses to draw to your attention the realization that organization is necessary, and to further draw your attention to these let us consider the factors that enter into motor transportation enterprises, none of which can be neglected to any great degree if the outfits are to be economically operated and maintained. I know of no better presentation of them than the outline shown in Chart No. 1, which chart was recently presented in a paper before the S. A. E. by Mr. M. C. Horine.

The factors presented by Mr. Horine cover a wide range of consideration and necessitate a general knowledge of:

- Highway engineering
- Mechanical engineering
- Automobile engineering
- Electrical engineering
- Transportation
- Bookkeeping
- State laws, etc.

However, Mr. Horine neglected to include the human element side of the question in his table of economic factors, which I consider has an important bearing on the efficiency of any operation. So much general knowl-

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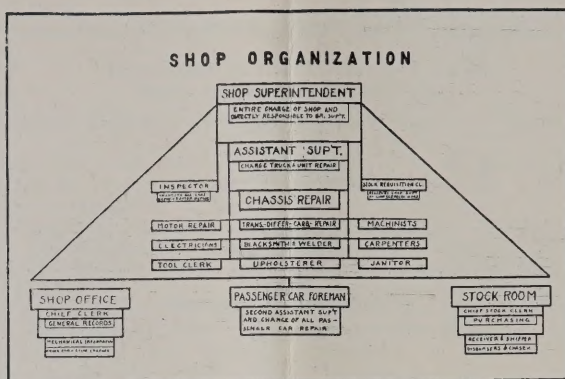


Chart No. 3

This chart shows the approximate plan on which all the motor vehicle shops of the Standard Oil Company are operated. (see second column below)

edge is known about an automobile by the general public, yet, there are few specialists who understand the fundamentals of the various factors that careful selection and training is necessary if the organization is to be efficient.

The organizer of a department of any size should have a knowledge of man-power, and understand the psychological elements of organization in order that harmony and team-work may prevail, without which discipline and the possibility of economical operation would be at a premium.

These specialists all co-ordinate the activities of the motor vehicle in an economical way with the rest of the business. The type and extent of the organization which one would adopt depends to a large degree on the number of vehicles to be operated and the extent of the territory which they cover.

Each type of industry, whether it be a contracting concern, silk, express or oil business, has surrounding it certain business conditions with which the supervisor of motor vehicles must be more or less familiar.

For instance, in road building it is not only necessary that a man have a general knowledge of the motor vehicle itself, but it is also necessary, if he is called upon to make an installation of any vehicle for road oil or binder distribution, that he have a general knowledge of the material to be applied by the vehicle and the various types of pumps that might be used for its application. His other general engineering knowledge would fit him to work up a design that would be suitable from a mechanical standpoint. The conditions surrounding an installation of this kind would be mounting, driving and gearing the pump so that it would be practical to operate, accessible, economical to maintain, and capable of giving the proper volume distribution for the various types of work encountered by the vehicle.

Organization Chart (No. 2)

I do not presume to outline to you the type of organization that might fit your varying conditions but I will present for your consideration an organization chart which provides for the handling of approximately 1,200 to 1,300 vehicles which are operated over a widely scattered territory in the States of New Jersey, Maryland, District of Columbia, Virginia, West Virginia, North and South Carolina, and which vehicles are under centralized control.

This organization chart is the result of ten or twelve years' direct experience in motor transportation, and the vehicles under this plan are being operated in direct competition with other types of transportation, namely: horse-drawn and steam. In at least 98 per cent. of the cases each outfit is doing the work, at least within a slight margin, more economically than it could be done by any other form of hauling.

This chart indicates that the branch of the company in which these vehicles are being operated is a sales organization, and the relation of the motor vehicle department to the balance of the organization.

The chart also indicates that the Superintendent of vehicles has directly under his supervision men who handle the inspection and mechanical upkeep of the

outfits, and that he is responsible for the installation of the various types of motor vehicles, and, while not directly responsible himself for the vehicle operators, he is in direct touch with them through education and the auto inspectors who visit periodically all of the outfits.

The output from the vehicles is directly up to the Branch Sales Manager through the Route Foremen, and the gathering together of the reports turned in by the two departments is under the supervision of the Accounting Department.

The painting of the vehicles is done by the Construction Department, in most cases, for economic reasons.

Chart No. 3

Chart No. 3 clearly shows the approximate plan on which all of our shops are operated. In forming a shop organization, one has to take into consideration the fact that in automobile work practically all branches of the mechanical arts are encountered. A man who superintends this work should be one who has fundamentally been educated to think along mechanical lines. I prefer one who has served an apprenticeship as a machinist or tool-maker, and has educated himself along engineering lines. He may be called upon to consider problems wherein the following lines of work may have to be considered:

- Designing
- Pattern making
- Foundry practice
- Machine shop practice
- Tool-making practice
- Blacksmith practice
- Electrical
- Painting
- Tinsmith
- Wheelwright
- Body building
- Carpenter
- Upholstering
- Stockkeeping
- Service problems, etc.

A man so equipped will be in a position which will tend to make him resourceful and capable of instituting many short-cut methods, which will result in a large yearly saving. He should, along with his mechanical training, possess those qualities which fit him to instill in others a desire to perform their duties in a harmonious, careful and conscientious manner.

The outline as shown presents a practical working organization which is in operation and is producing economical results.

Installation

When a vehicle is to be purchased, the type of work and the country into which it is to be installed are carefully studied from the various angles pertaining to an efficient installation.

In my particular line, a canvas is made of the approximate number of gallons or packages that will be delivered in the respective territory under consideration. We study, particularly, the adaptability of the road to carry it so that we may have installed the proper transmission

SHOP REPORT OF

[illegible]

This weekly shop report materially assists in checking up the shop activities and provides an index of the work accomplished. (see page 22)

In the operation careful study has to be made of the various factors noted in the chart. Particular care

They maintain constant schedules and visit a truck periodically. One inspector will take care of from fifteen to twenty-four vehicles, depending on the type,

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the amount of territory they have to cover, for it is obvious that a man can take care of a much larger number of vehicles operating from a central garage than one who has to visit a number of plants or stations.

Besides being responsible for the mechanical condition of the truck, our inspector has to examine for proficiency all men who are employed as operators. He is held responsible for any neglect which may result in our having a vehicle go on the road which presents other than a first-class appearance, and reports any irregularities and indifference exhibited toward the rules that are laid down for the motor vehicle operators' guidance.

Repairs

Provisions are made to overhaul the vehicles when needed in a central repair shop, of which an organization chart has been shown. Outfits are brought in for repairs during off seasons, or are replaced by "reserve" equipment, which is held for this particular purpose. Every effort is made to plan the movement into the shop so that the outfit will receive prompt attention. The progress of the work is checked by a weekly Shop Report, illustrated in Figure No. 6, which materially assists in checking up the shop activities and provides an index of work accomplished.

To obtain the most economical results, it is best to adopt the unit repair basis. This provides for the carrying of a number of complete units which can be readily substituted for the worn parts, and the worn parts can be undergoing repairs after the chassis is in the paint shop or on the road.

Repair Shop

The shops are divided into departments, such as chassis, motor, gear box, rear axles, electrical, overhaul and a competent specialist is engaged for these respective duties. As a department grows, the old employee should be worked into a position of working foreman. This training should fit him to assume greater responsibilities. I find that more accurate and economical results are obtained under this method than by permitting a man to do all-round work, and, besides, through this system it is possible to detect the source of poor workmanship or failures.

Inspection is provided in each department through the activities of the foreman and final inspection of the complete job is provided for by a man who is entirely responsible to the Superintendent alone for the passing out of work.

Service

Necessarily in an organization of this kind emergency service has to be provided. This is done by carrying a stock of parts at the main repair shop, and in small quantities at strategically located points. At the main station this stock-room provides for the shop needs, which facilitates repairs. In any organization where constant service by the vehicle is an asset, an efficient stock or service depot is a wonderful thing. It provides a means for filling wants in any emergency which places the vehicle in a position to operate at all time.

To provide proper service it is necessary that correct mechanical information be kept on file, and changes in the mechanical condition of a vehicle kept up to date. We provide for this by having a complete set of specification sheets, furnished by the vehicle manufacturer, which is filed with a standard mechanical information sheet as shown by Fig. No. —. If these records are properly maintained the service man has a ready reference for each vehicle, which will remove a great possibility of incorrect parts being supplied.

Painting

A well kept truck should be kept painted periodically. Paint protects the wood and metal surfaces from the elements, and provides a means for increasing the value of the vehicle by making it a traveling advertisement. As I travel I am often surprised to note that some concerns pay many dollars for select sign locations along highways, etc., and then neglect their motor equipment. If advertising pays, I can conceive of no better medium than a well-kept vehicle which daily encounters many more people than the average signboard.

A Paint Shop should be well ventilated, have dust proof varnish rooms, and have facilities for rapid drying, although some wonderful results are accomplished along these lines by small shops with limited facilities.

Accounting

That the officials may know just what each vehicle is doing, and be provided with a basis of comparison with other mediums of transportation, accounting is necessary. Any system should be as simple as possible, yet provide a clear and distinct method of comparison. We do this by summarizing our entire figures on the sheet shown in Fig. No. —. This form analyzes where the money is spent on the vehicle, and the results are shown in groups, by makes, capacity, style of service, and year of installation. It is a progressive record from which can be determined a group performance after a number of years' service as compared with its first year. This is a semi-annual report.

Care is taken through a carefully prepared primer, to see that proper distribution of charges are made.

To compile this report necessitates a group of auxiliary forms, some of which show in minute detail the efficiency of the Department, or work being performed. These include:

- Delivery,
- Mileage Run,
- Gasoline Consumption,
- Stock-keeping Records,
- Analysis of Distribution in the Central Shop,
- Analysis of Inspectors' Time and Expenses,
- Tire Records,

and others from which we can minutely dissect the vehicle's efficiency from any angle that might be required.

We do no unnecessary work. As for instance, you will notice that no mention is made on the form in Fig. No. —, of Cost per ton mile, but if for any reason this is desired, we can work out a particular example from the information at hand.

Tire Record

Accurate records are kept of the various types of tires used. Tires are bought on an adjustment, or on a guaranteed price per mile basis. In order that the tires may be properly adjusted and that we may be in a position to compare the relative merits of one make with another, it is necessary that these records be maintained. The forms used in doing this are illustrated in group No. —.

Provision is made for taking care of the various types of tire equipment. In the case of solid or cushion tire equipment, a report is made when a tire is applied and its record is kept in the office on the solid tire record. In the case of solid or cushion tires, when once applied to a wheel, they remain there until finally worn out, with but few exceptions. These records are easy to keep as compared with those necessary for pneumatic tires.

Pneumatic tires, which are apt to come to grief through puncture, etc., require more detailed care on the part of the operator, and to assist him in keeping proper records we supply a definite set of forms which are illustrated in Fig. No. —. These forms facilitate the operator keeping an accurate record, and when a tire is sent in to a central stock room to be adjusted, it is taken care of through a special form of tag, which is used as a shipping and mailing tag. This tag is so arranged that it can be torn in sections when about to be used, and one of the stubs, bearing the same serial number as that part which has been sent through the mail and on the tire, is retained by the operator. Through this tag we are able to check shipments and mileage very accurately.

While it may seem to some that the expense involved is not justified, my experience clearly shows that accurate records of this description should be kept. It is surprising to note the large saving that can be effected with some types of tires as compared with others, both from a standpoint of Tire Cost per Mile, and Mechanical or Repair Cost per Mile.

A summary of the mileage obtained from all tires is made up semi-monthly and turned in to headquarters. These records give us a comparison between the different types and makes of tires.

Provision is made through these detailed reports,

COMPARATIVE OPERATION COSTS

PREPARED FOR BRANCHES

[illegible]

Chart No. 7

This accounting form analyzes where the money spent on motor vehicles goes to and shows the results in groups; by makes; capacity; type of service; year of installation. A semi-annual report is made from these items. (see page 22)

for the various executives of the organization to keep in intimate touch, through analytical forms as shown in Fig. No. —.

Accounting forms may be obtained economically from various sources, and in the majority of instances; under standard methods laid down it will be found that approximately two-thirds of the charges are so-called "Fixed Charges," and one-third "Variable Charges."

I call this to your attention, because if economy is to be obtained, the Moving Load and Active Factors are the ones which should receive close attention. Because a vehicle is a mechanical device these are often overlooked, and great stress is laid upon the maintenance and up-keep factors. These latter factors in modern machines will remain practically constant, provided speeding and overloading are eliminated.

The problem of material transfers and interurban delivery by motor truck, and the feasibility of employing motor buses is becoming more generally recognized by some of the larger companies. This is indicated by the desire of some of the larger old line railroads and transportation companies having in mind the adoption of unit carriers, which can readily be

transferred to motor vehicles. One such installation, I understand, is being made by the Erie R. R. for the transfer of material between its Jersey City yards and New York City, and I believe other railroads have similar installations in mind. Traction companies are realizing that the buses can be adopted with profit, to act as feeders for its main trolley lines. These installations are being made only after a careful study of all angles pertaining to the problem, and there is no doubt but what the future will bring forth a considerable growth along these lines. The possibilities of this type of transportation call for greater co-operation among all affected, and the industry as a whole should not be judged by past performances of many irresponsible operators, who, because of selfish interests, have not taken into consideration the rights of the public at large, which resulted in abuses springing up that have caused a general feeling of hostility towards this type of transportation. There is need for a greater co-operation if the operating problem is to be satisfactorily solved. Excessive taxation and restrictive laws which seem to be springing into existence over the country, will only result in the throttling of an industry, which is yet in its infancy.

Discussion of Mr. Winchester's Paper

By Norman C. Applegate, Superintendent of Equipment, N. J. State Highway Department

Mr. Winchester is to be complimented on such an excellent paper. The subject has been very thoroughly covered.

The biggest equipment problem that confronts the modern Highway Department is "Snow Removal."

A more complete and thorough organization is required for, and more wear and tear on equipment is sustained in one eight or ten-inch snow-storm than in a whole season's ordinary work of construction and maintenance.

In discussing the paper your attention is directed to several conditions under which we are working which make our organization differ somewhat from that as outlined.

The organization as outlined by Mr. Winchester takes care of approximately 1,300 vehicles distributed over seven States, all of which are under his direct control.

The State Highway Department has a total of 417 motor vehicles, that is, light cars and trucks, and in addition also has approximately 175 other pieces of power equipment, including rollers, tractors, concrete mixers, steam shovels, pumps, etc., under the direct control for care and operation of the Equipment Division.

The Equipment Division acts as a trucking or equipment contractor to the other State divisions, such as Maintenance, Construction, Bridge, etc., and has full charge of maintenance and care and method of operation of equipment. The operators of these vehicles work under the supervision of the various superintendents, foremen and engineers as to hours worked and work done.

Installation

In reference to the installation of new types of equipment, this is a problem that we have not as yet had to go into very deeply. Practically the only installation in the last year has been the purchase of several Ford ton trucks and survey cars, which trucks and cars cover a field by themselves in which no other type of equipment would be suitable. In reference to the installation of the larger type of equipment, all the heavier motor vehicles now in use by the Highway Department are war surplus material. In the distribution or assignment of these vehicles to the various jobs around the State various local conditions, such as amount of material, approximate haul, source of material, whether new construction or maintenance work, and approximate length of time vehicle will be used on that particular job, are all taken in consideration.

Standardization

The question of standardization is another problem which does not immediately interest us due to war surplus material on hand. When six or eight trucks are sent out to take care of a particular job we endeavor to have all trucks of the same make and type in order to simplify the work of the mechanic in taking care of them. In reference to heavier trucks, we are now using fifteen different makes of trucks and six different makes of touring cars. As stated before, practically all equipment is war surplus material, which has been transferred to the State at nominal cost. However, on gravel maintenance work and maintenance patrol units we have practically standardized on Ford ton trucks with the tilting hand-dump body.

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The question of installation and standardization also becomes difficult, due to the fact that the work on the various jobs throughout the State is not constant. Irregular receipt of material by freight also handicaps us in selection of the type of motor equipment to be sent out on the job as the truck may be used to haul material for several days and either lie idle, be used for cold patch work, or to transport laborers for several days while waiting for material.

Control

Locations of every piece of equipment are kept posted on a large map of the State showing the different highway routes. Different colored and size map tacks with the various department numbers printed on them are used to denote different types of equipment. These tacks are spotted on the map as near as possible to the actual place where equipment is located. The map which we use is on a scale of approximately one-half inch to one mile. This map is posted within two or three days after changes in location are made. A card system is also kept which gives full information regarding the piece of equipment together with the dates the locations of same are changed.

Operation

As I understand it, the work of the Standard Oil is practically the same through the entire year, and the trucks are permanently assigned to one headquarters. In our work the season is about seven or eight months long and outside of a few isolated cases the truck would not be in one location on the average for more than three or four months. This makes it difficult to procure and keep competent drivers of the type which you require in your work. Practically every time that the location of a truck is changed it becomes necessary to change drivers, due to the fact that the older men object to working away from home and the short season. Most of the drivers want the all-the-year-round outside work and object to being placed in the shop throughout the winter season.

Vehicle Inspection

Our inspection was taken care of in the past year by one inspector, who covered the entire State. He was able to make the trip once in two weeks. This inspector's duties were as follows: To inspect and make a report as to care taken of equipment and method of operation and report same to the Equipment Office; also to make whatever minor adjustments were necessary. He did not, however, do any repair work on these trucks, but in cases where he found it necessary he would phone the central garage, Trenton, and a service mechanic with repair parts would be sent out to take care of the trouble. This year, on account of additional equipment in use, we are planning to divide the State into four districts, each of which would contain between 150 to 200 miles of State highway. One mechanic, or, if necessary, mechanic and helper, would be assigned to each one of these sections to make all necessary inspections and repairs on equipment. They would be held responsible for all equipment in their territory. Only in cases of extraordinary trouble, such as serious motor or transmission trouble, where it was necessary to bring the unit into the shop for repairs, would the garage forces be required. In connection with the above, I would like to ask several questions: Do inspectors do the actual work? If so, to what extent? Also, would like to know as to the average pay of the type of drivers which you employ and whether paid on the monthly or hourly basis? Do you find

drivers competent to make inspection as outlined on your inspection sheet? And are results satisfactory?

Repairs

We have one central repair shop which is located at Trenton. Practically any part of the State can be reached by a service man with parts necessary within three or four hours at the most from here. Sufficient stock is carried at our central service station to take care of all except extraordinary repairs on all types of equipment which we operate, except touring cars, on which we can get service at several different places in the State. Our repair work is taken care of in a different way than yours, due to the fact that our equipment is tied up practically throughout the entire season. While not actually working during the four or five months in the winter, when they are taken off the road work, these trucks, immediately after the road season, are brought into the garage and equipped with snow plows and sent out and kept available at all times for snow removal. Up until the present season we have not had enough equipment "as reserve" to enable us to replace equipment out on snow removal while these trucks were being overhauled.

Service

As stated in a previous paragraph, parts are carried in our service station for all makes of trucks. We have not found it practical to depend on Philadelphia or New York stock for truck repair parts, as in several instances we have found it necessary to secure these from factories located several hundred miles from Trenton.

Accounting

At present our accounting and costs are distributed in a general way as follows:

Operation of Trucks—This means that operating costs for all trucks are lumped together with no distinction made between different makes and sizes. In like manner, all other equipment is lumped, that is, all costs for steam shovels, mixers, road rollers, pumps, etc., are grouped under the general head, "Operation of Equipment," and it is not possible to segregate different types and makes of equipment. It is my opinion that individual costs should be distributed as follows:

- Inside repairs
- Outside repairs
- Gas and oil
- Tires
- Operators' salaries
- Operators' expenses.

The above should be compiled for each piece of equipment each month. This information is necessary for the intelligent working of equipment.

Tire Record

At present tires are furnished to us under competitive bidding. In the past very few tire records have been kept due to the fact that the adjustments which we were able to get under the agreement under which the tires were bought, made the cost of keeping records of tires equal or more than actual benefits that we received from any adjustments.

In general, the article by Mr. Winchester very thoroughly and fully covers the field of motor truck transportation and organization. He leaves very little in the field open for discussion except for the conditions as noted above, which conditions are those under which we are working at the present time, and which make our organizations differ somewhat.

I believe that transportation by motor vehicles offers one of the biggest fields for efficient organization.

